Nuclear Modification on Two Particle Azimuthal Correlations at Forward/Backward Rapidities in $s_{NN}^{1/2} = 200$ GeV *d+Au*

Chun Zhang

Oak Ridge National Lab.

For the PHENIX Collaboration

Outline

- **Basic Physics involved**
- **What we measure**
- **Summary and discussion**

The suppression of hadron production at forward rapidity in d+Au

RHIC experiments have observed a suppression of hadron production relative to binary collision scaling in deuteron-gold reaction at forward rapidity sensitive to low x partons in the gold nucleus, (e.g. see the PHENIX results at Phys.Rev.Lett.94:082302,2005).

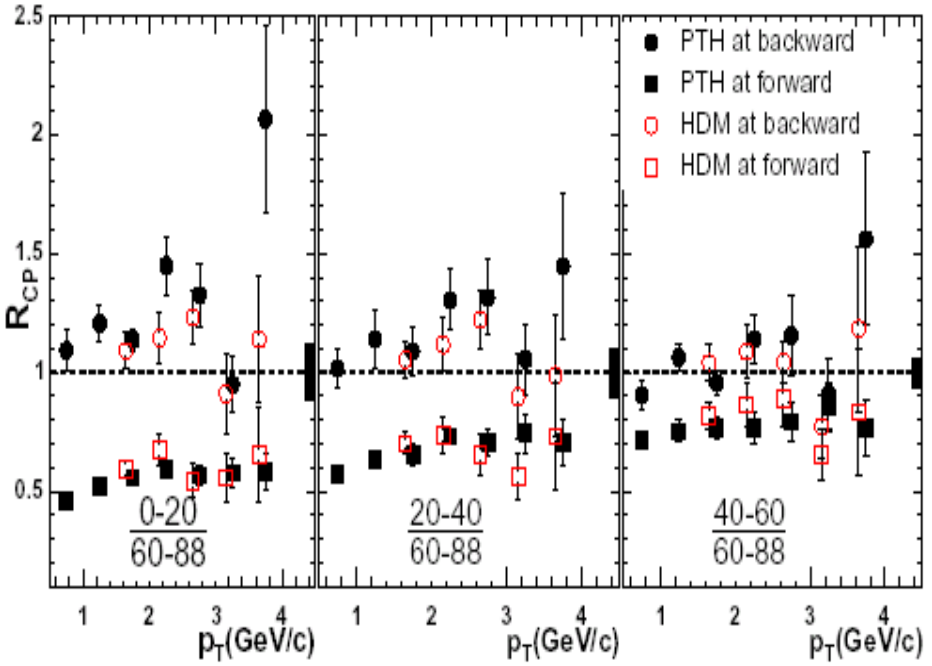


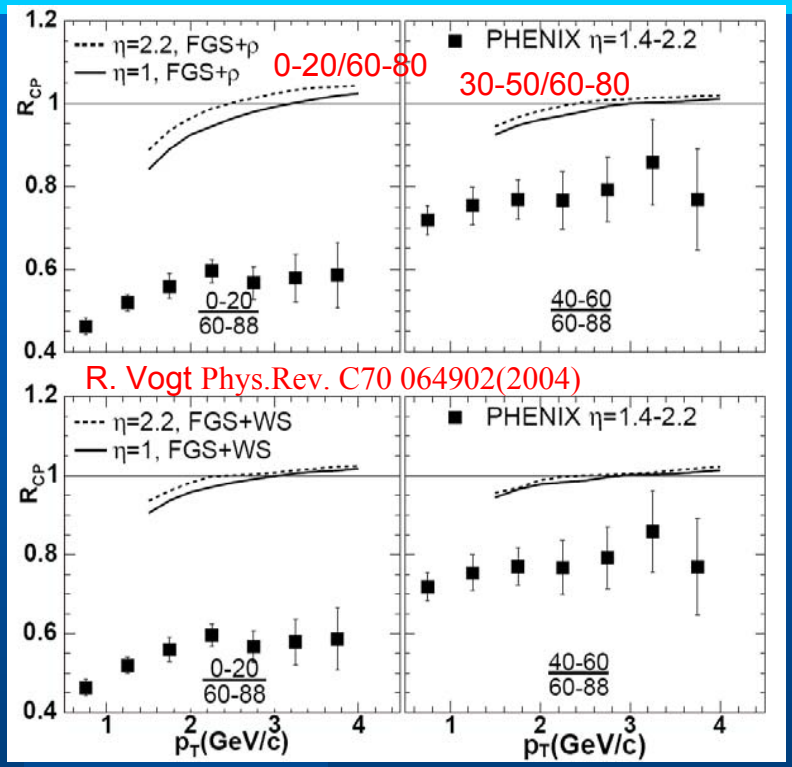
FIG. 2: (color online). R_{cp} as a function of p_T at forward rapidity (squares) and backward rapidity (circles) for different centrality classes.

Theoretic models

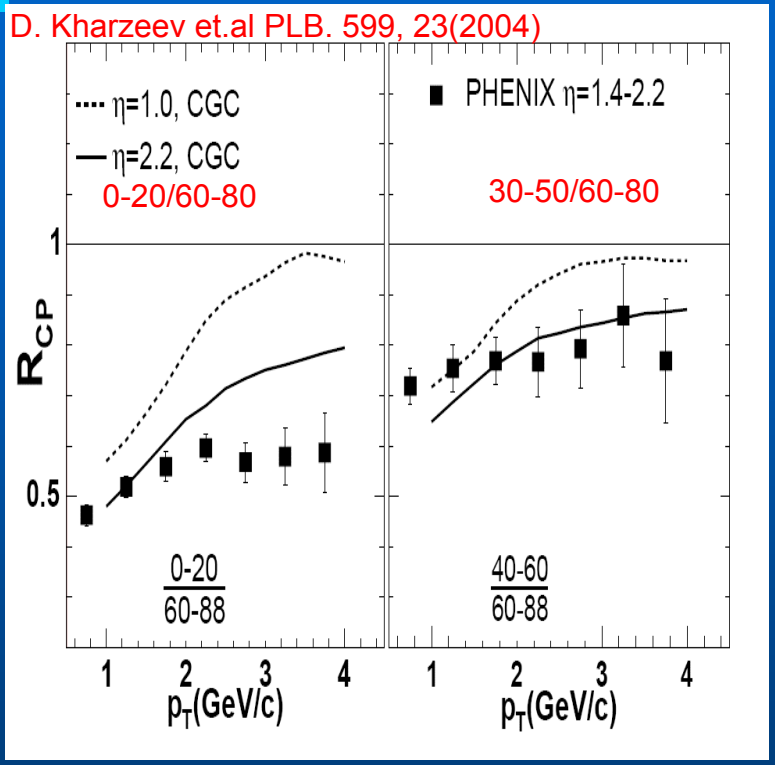
- Possible theoretic explanations for forward suppression.

1. Color Glass Condensate(CGC). Gluon density is saturated at small x.
   D. Kharzeev, Y. Kovchegov and Kirill Tuchin. Phys.Lett. B599 (2004)23-31
2. Power Correction. Dynamic Shadowing.
   Jianwei Qu, Ivan Vitev **Phys.Rev.Lett.93:262301,2004**
3. Leading twist shadowing.
   R. Vogt Phys.Rev. C70 064902(2004)
4. Recombination.
   Rudolph C. Hwa, C. B. Yang and R. J. Fries Phys. Rev. C71, 024902(2005)

Comparison with CGC and leading twist



D. Kharzeev et.al PLB. 599, 23(2004)



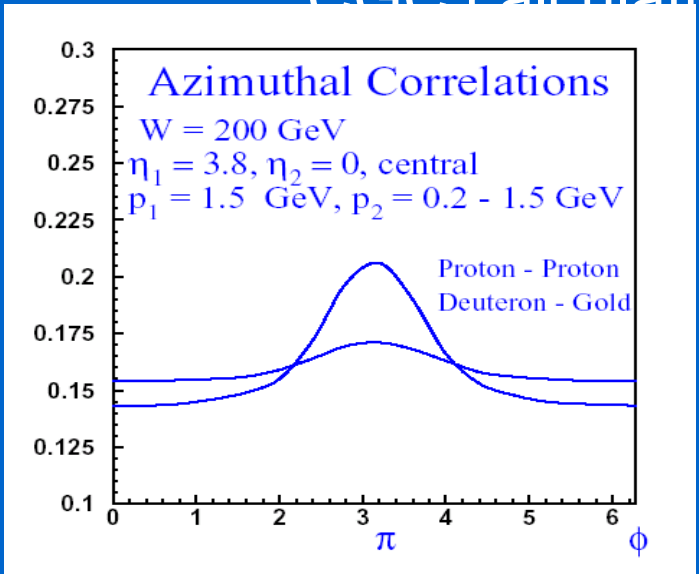
ρ assumes shadowing stems from the multiple interactions of the incident partons.
ws assumes that shadowing is proportional to the local density.

The CGC calculation has two free parameters, which are fixed by fitting the BRAHMS results.

CGC jet depletion

•CGC and power correction also predict the depletion of back-to-back jet yields if the two sides of jets are separated by units of rapidities.

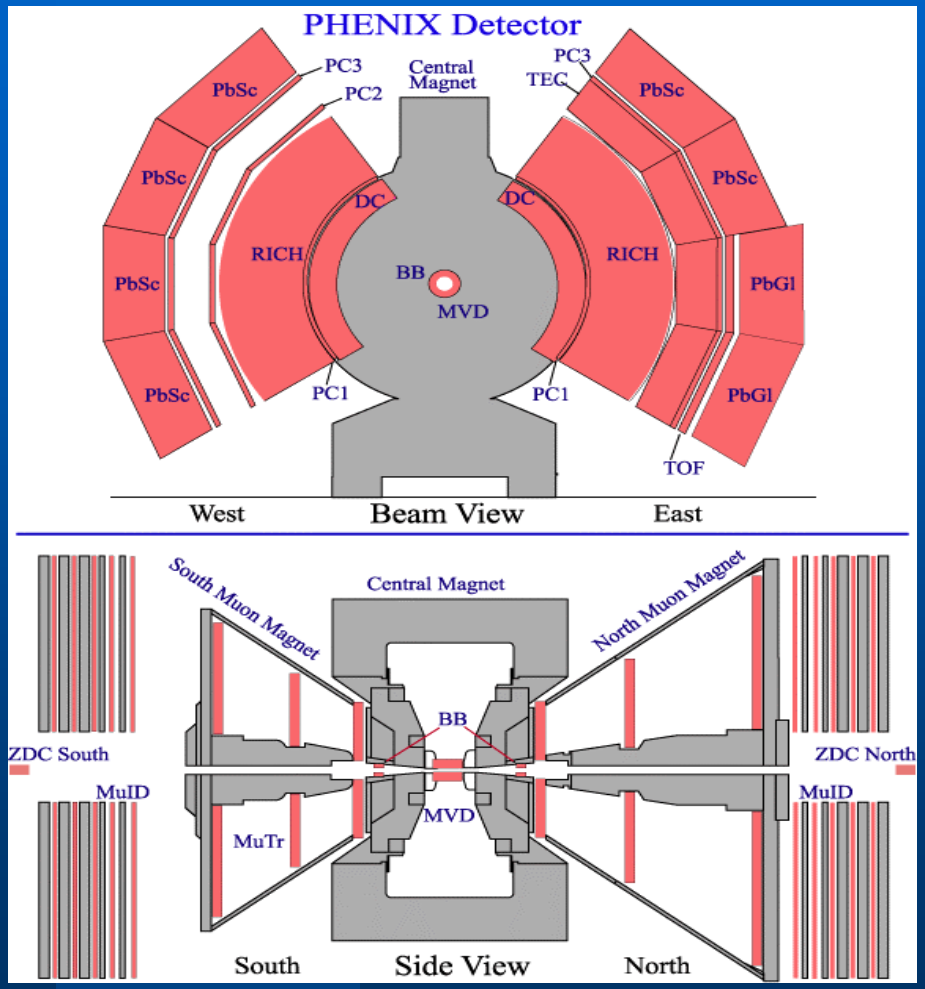
CGC calculation



Trigger particle at forward rapidity (1) and associated particles at mid-rapidity (2).

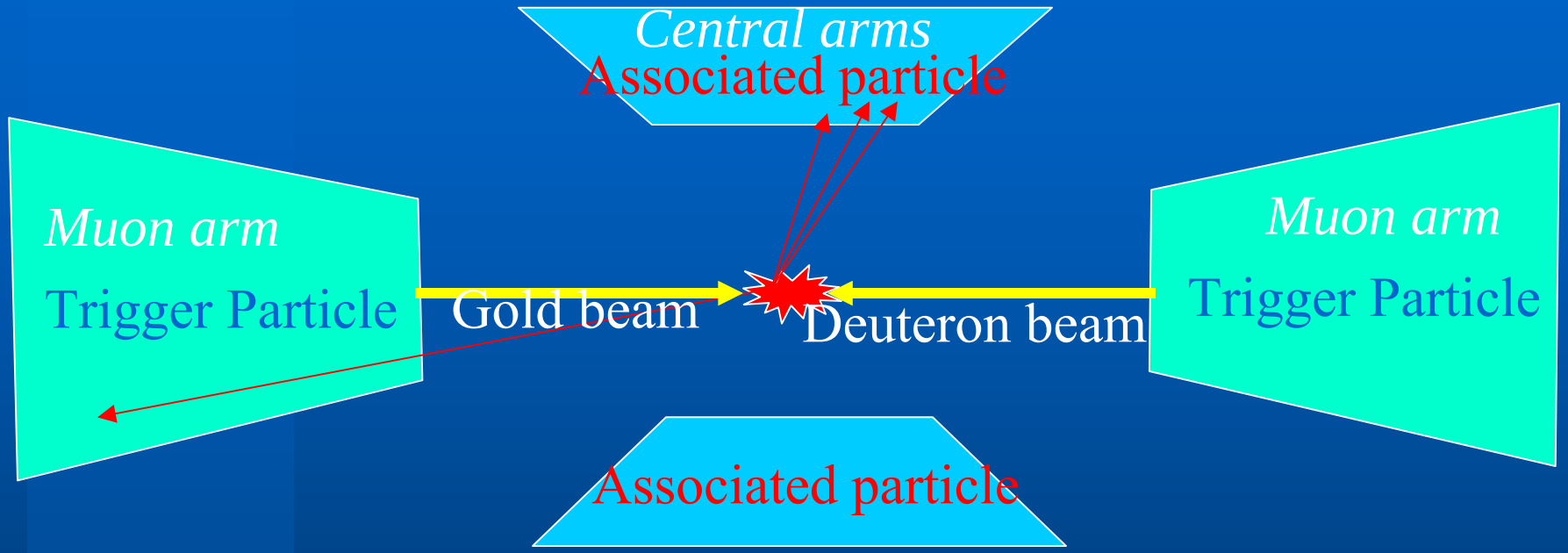
Dmitri Kharzeev, Eugene Levin, Larry McLerran Nucl.Phys. A748 (2005) 627-640

The PHENIX detector



- The PHENIX central arm detector system covers $|\eta| < 0.35$. It is able to measure hadrons, electrons, photons.
- The PHENIX muon arms cover $-2.2 < \eta < -1.2$ and $1.2 < \eta < 2.4$. They are designed to measure muons, but they also have the ability to measure light mesons, such as pions and kaons.

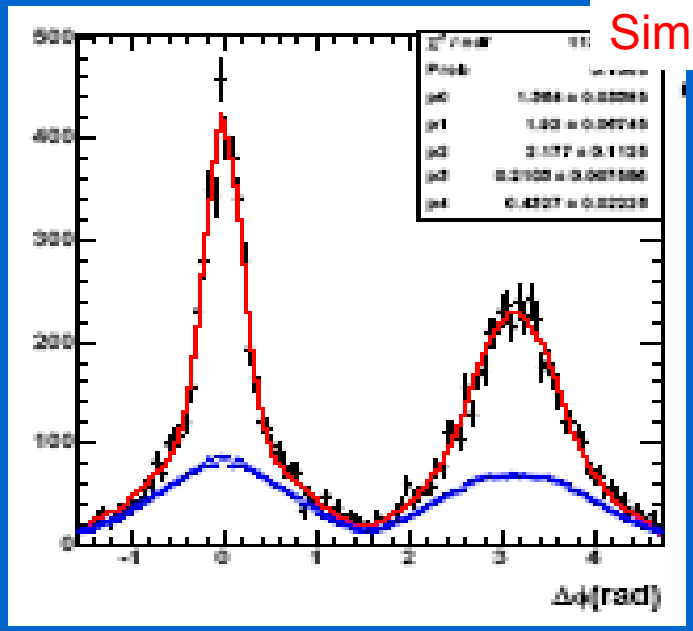
The kinematics of this measurement

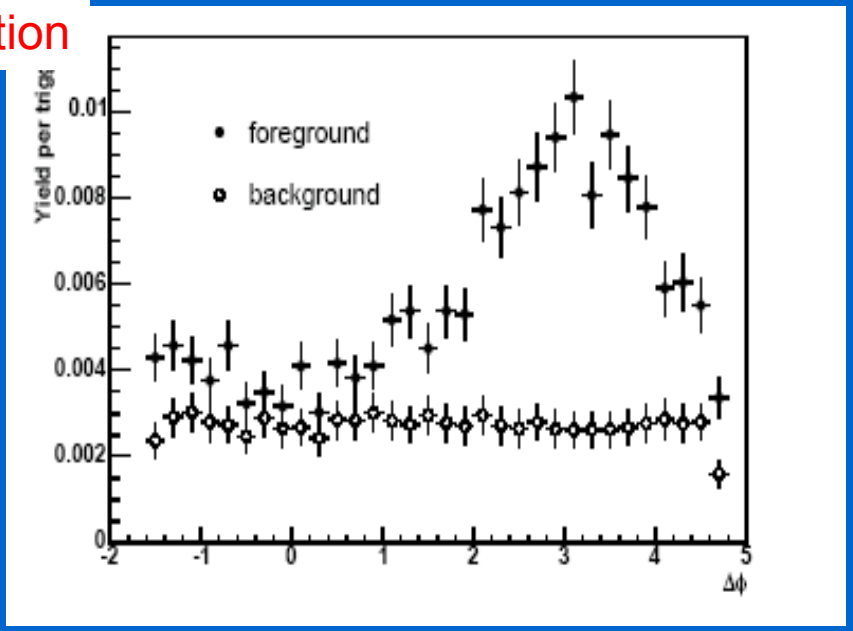


- We trigger on jet event by looking for charged hadrons from muon arms with $1.4 < |\eta^{trig}| < 2.0$ and $1.0 < p_T^{trig} < 5.0$ GeV/c
- The back-to back jets are identified by looking for charged hadrons in central arms($|\eta| < 0.35$). True back-to-back jet signals have the distances between trigger particles and associated particles in azimuthal space, $\Delta\Phi$, are around π.
- There is a rapidity gap between trigger particles and associated particles(> 1 unit rapidity), No near side correlations.

Simulation for jets separated by one unit of rapidity

Simulation

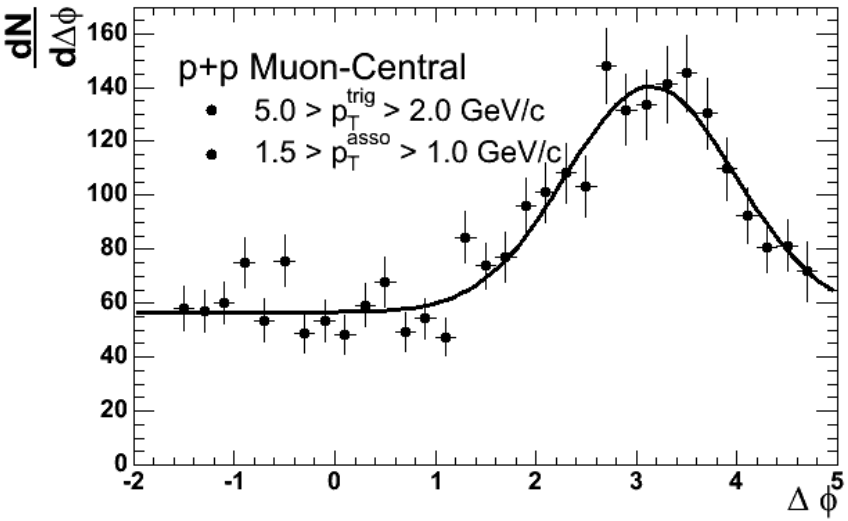


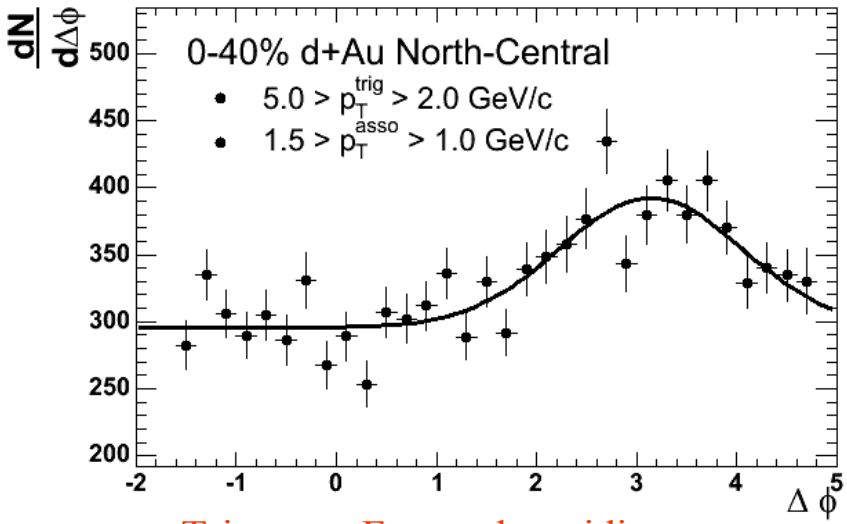


Trigger particle and associated particle at the same rapidity

Trigger particle and associated particle are separated by a rapidity gap

Correlation function and per trigger yield





Trigger at Forward rapidity

- The number of associated particles in away side jet is extracted by $N_{asso}(\pi - 1 < \Delta\phi < \pi + 1) - N_{asso}(-1 < \Delta\phi < +1)$ or by fitting the function with gaussian plus flat distribution.
- The strength of the correlation is quantified by N_{asso}/N_{trigg} per trigger yield

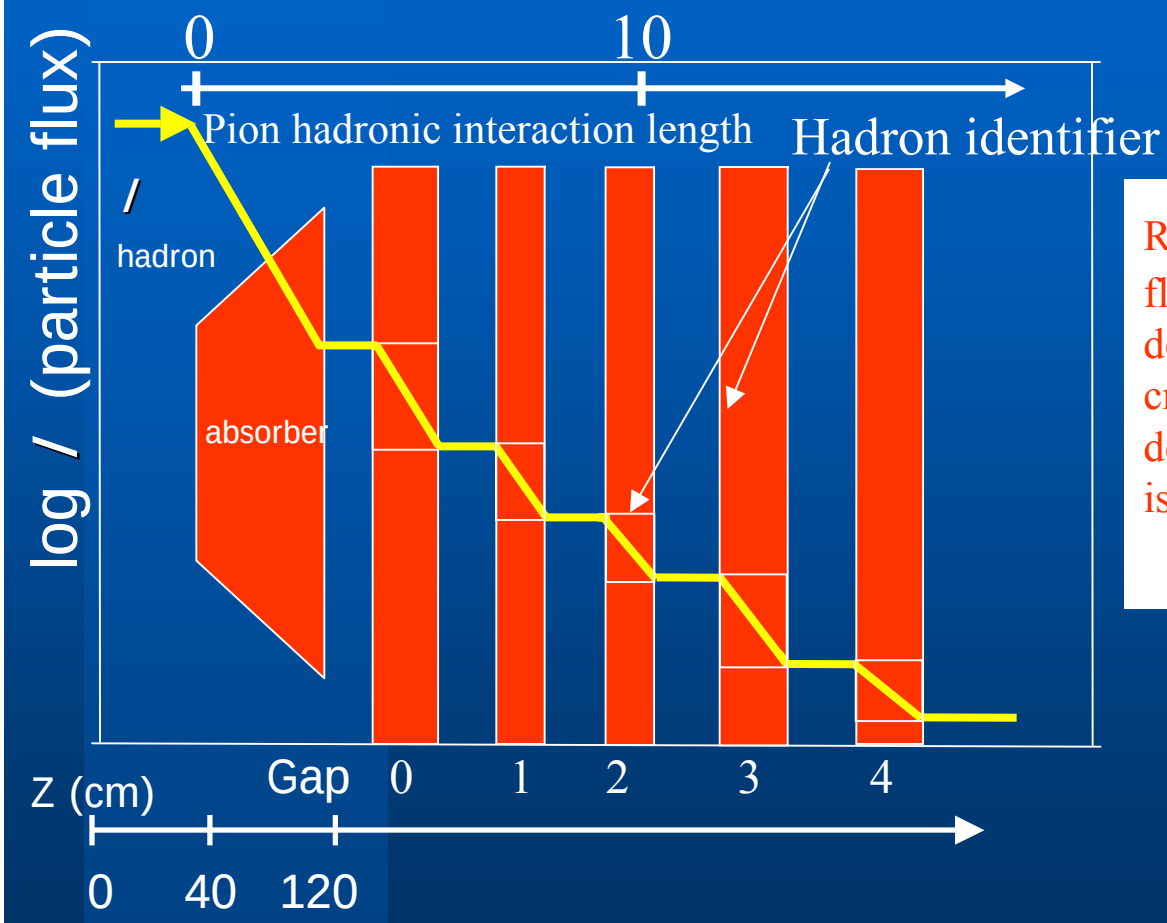
Nuclear Modification on Jet Correlation

Nuclear Modification on Jet Correlation is measured by comparing the jet strength in p+p collisions and the jet strength in specified event classes of d+Au collisions. It is defined as

$$I_{d+Au}^{c} = \frac{\frac{N_{asso}^{d+Au}}{N_{trig}^{d+Au}}}{\frac{N_{asso}^{p+p}}{N_{trig}^{p+p}}}$$

It is noted that there are two factors convolute into this quantity. The modification on jet production, such as jet multiplicity. The modification on single particle(trigger) production.

Trigger particle compositions



Ratio between of initial flux and the final flux at gap2/3, R_I for a particle species is determined by its hadronic interaction cross-section with the metrials and the decay $c\tau$. Thus the particle composition is modified by the material.

Trigger particle compositions

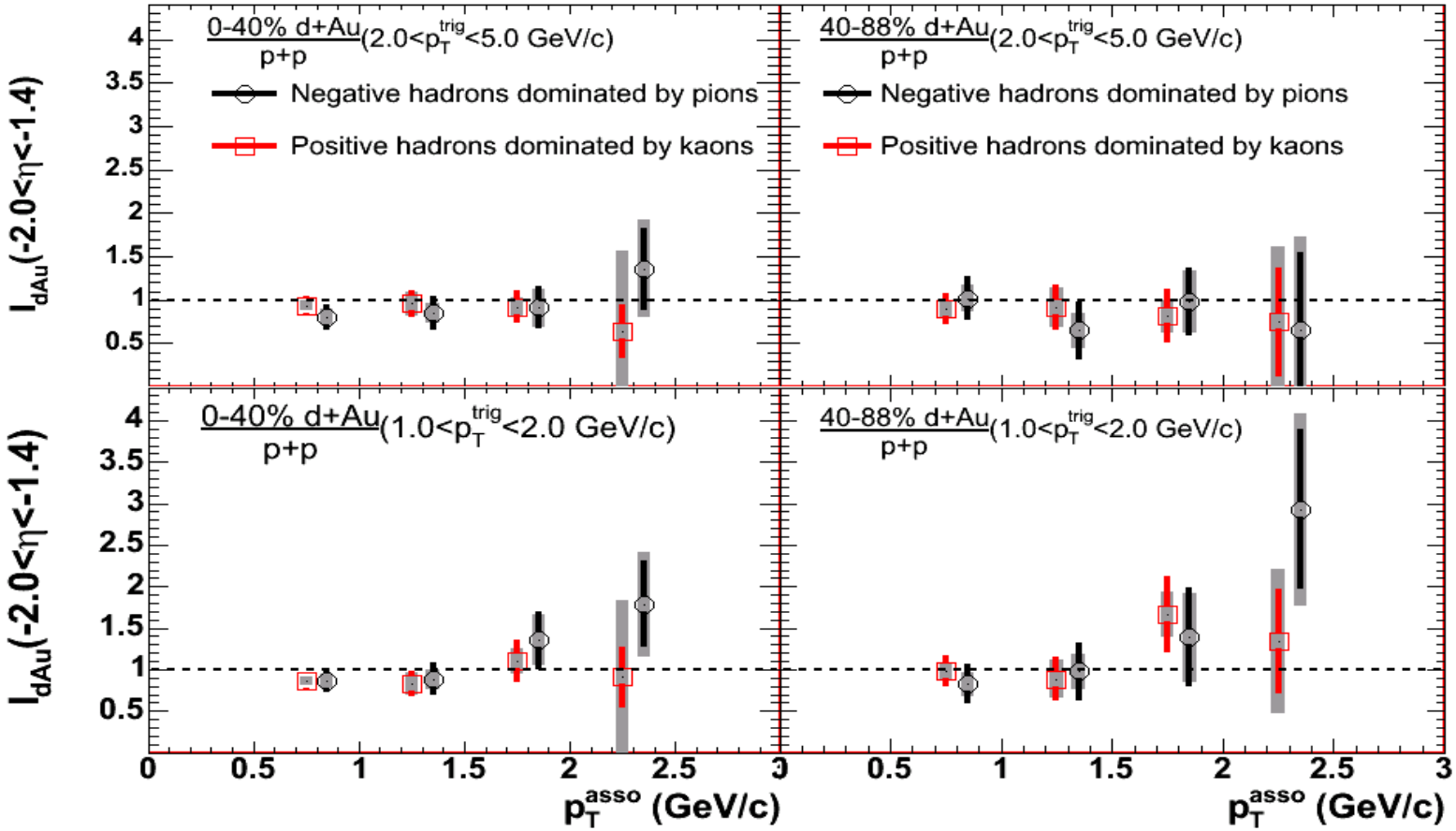
•We studied the particle compositions modification due our detector materials. In the study, we estimated the modification on the ratio between kaons/protons and same sign pions/hadrons. It is found for 3 GeV/c hadrons, pion hadronic cross-section on iron is 760mb.

	K^+(580mb)	P(870mb)	K-(760mb)	Anti-p (1400mb)
Ratio to pions @ vertex	0.3 0.8	0.3 0.8	0.3 0.8	0.3 0.8
Ratio to all same sign charged hadrons @ vertex	0.18 0.31	0.18 0.31	0.18 0.31	0.18 0.31
Ratio to pions @ gap 2/3	2.7 7.2	0.072 0.19	0.25 0.68	0.001 0.003
Ratio to all same sign charged hadrons @ gap 2/3	72% 88%	2% 3%	20% 40%	< 1% < 1%

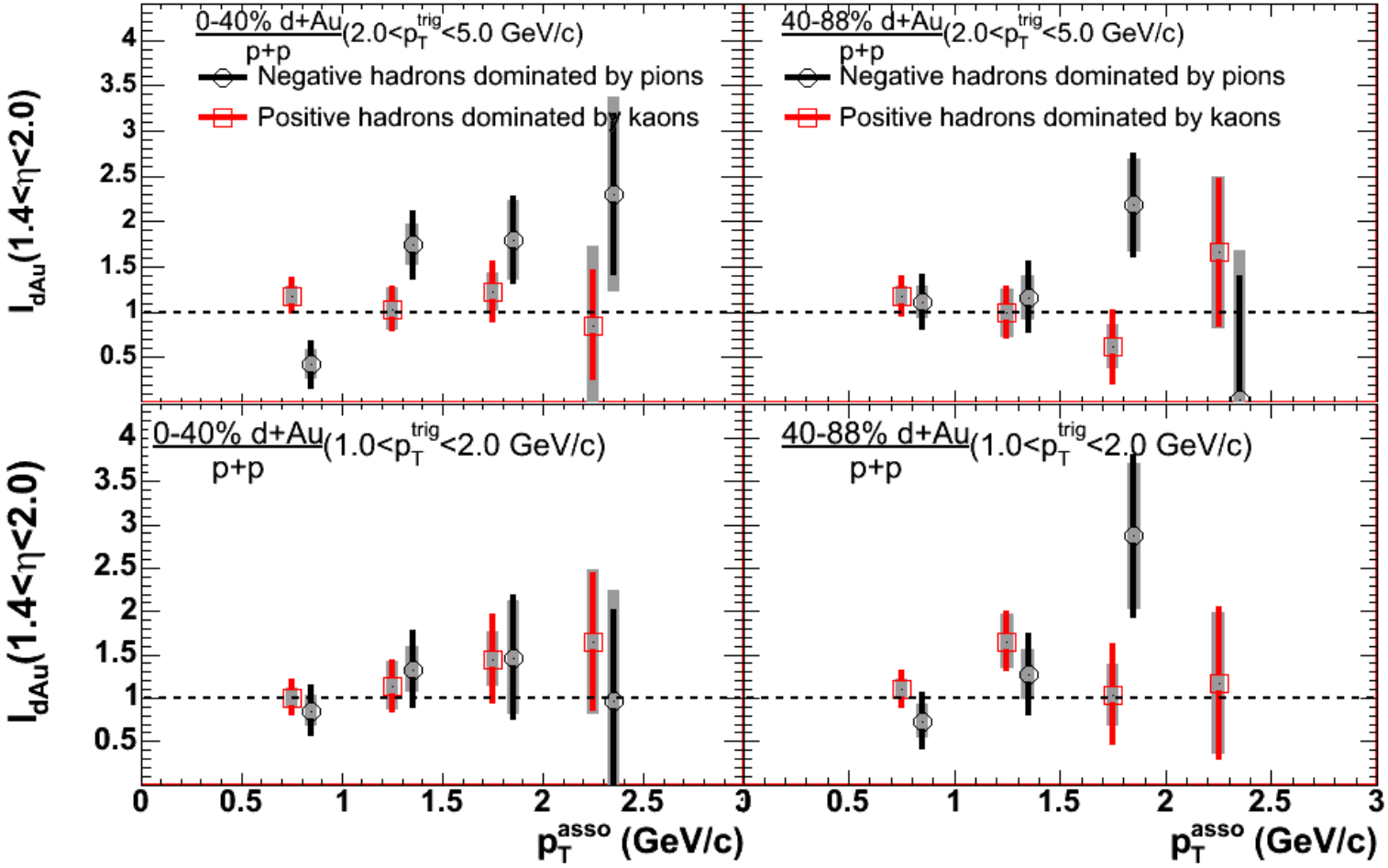
Our Trigger particles are dominantly light mesons

- **The trigger particles are over 90% light mesons.**
- **Positive trigger particles have different particle composition than negative trigger particles.**
- **For positives trigger particles, kaons are dominant. Negative trigger particles is mainly made of pions.**

I_{d+Au} at backward rapidities (gold ion direction) for positive trigger particles and negative trigger particles

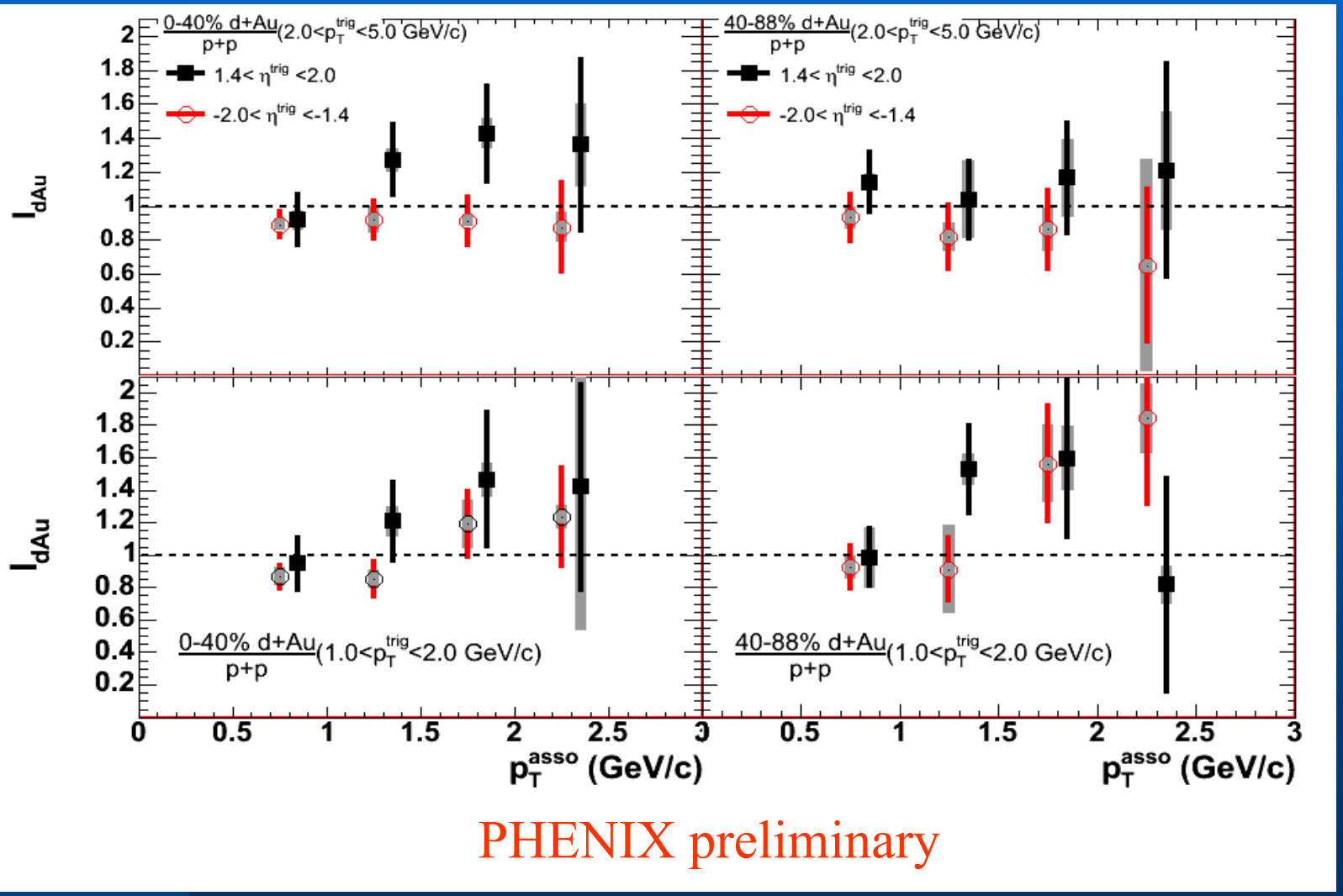


I_{d+Au} at forward rapidities (deuteron ion direction) for positive trigger particles and negative trigger particles



PHENIX preliminary

I_{d+Au} with combined statistics



PHENIX preliminary

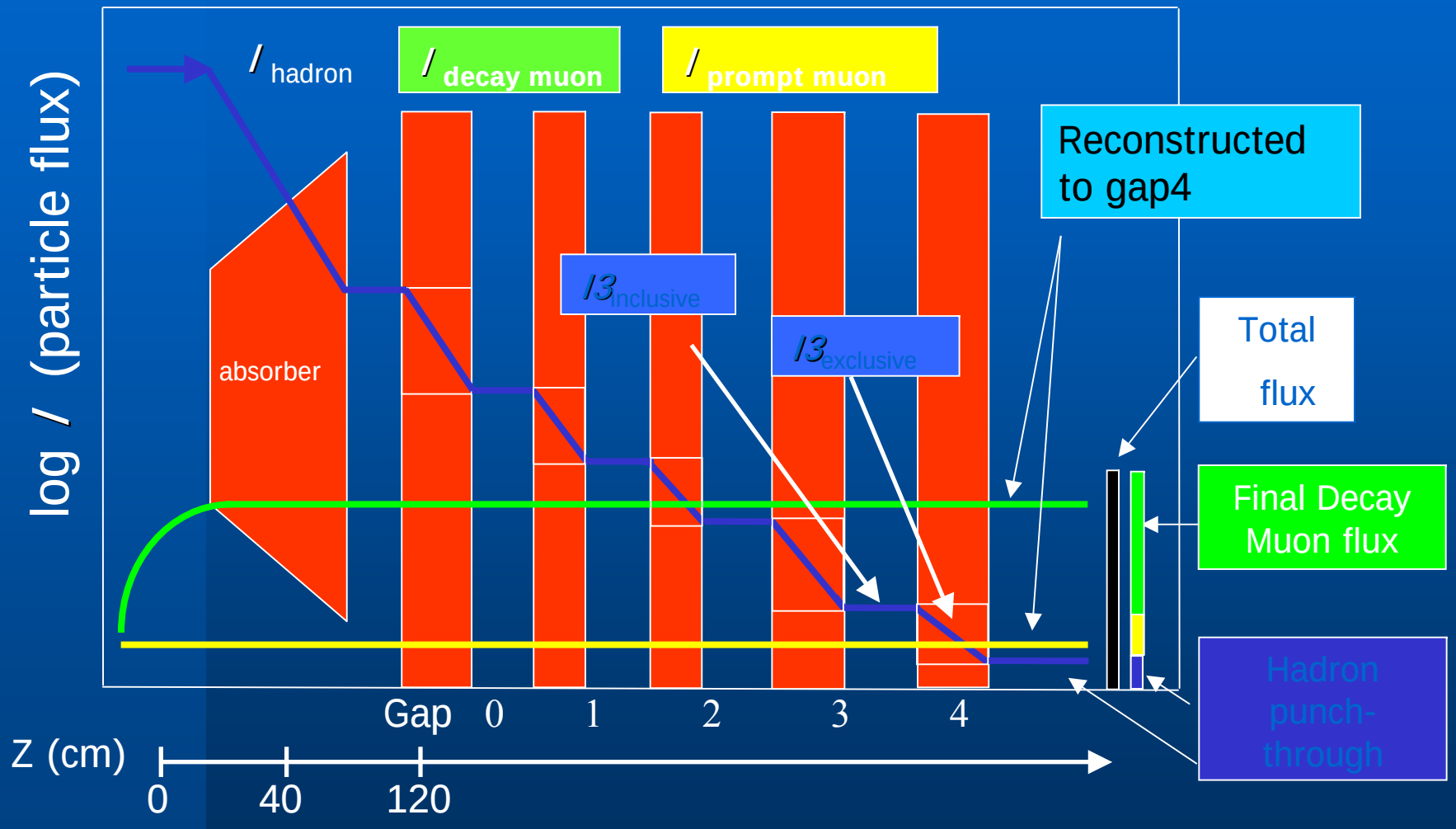
Summary and discussions

- **We do not see any strong nuclear modification on per trigger jet yield. Especially we do not see a depletion in per trigger jet yield when triggering at forward.**
- **In fact, at forward rapidity, our data seems to suggest a slight enhancement on per trigger jet yield in d+Au relative to p+p**
- **We noted that per trigger yield are determined by single particle production and jet production together. From single measurement, we know there is a strong suppression at forward rapidities in d+Au. Thus a slight enhancement on per trigger jet yield may suggest**

  1. Jet production is not modified.
  2. Jet production is also suppressed, but is less suppressed than single is.

backups

Total chart for all flux



Toy models

Suppose the trigger particles at this modest pT are a combination of "soft" particles (with no back-to-back jet partner) and "hard" particles (with back-to-back jet partners). Suppose the probability for an associated hadron at mid-rapidity at 180 degrees per "hard" trigger particle is unchanged from proton-proton to central deuteron-gold.In this case, our north arm data (which gives a hint of an enhancement) would be telling us that the fraction of "hard" hadrons in this pT range is larger in deuteron-gold than in proton-proton. This seems quite possible if we assume the "hard" production scales with nbinary and the soft production is shifting backwards in rapidity.

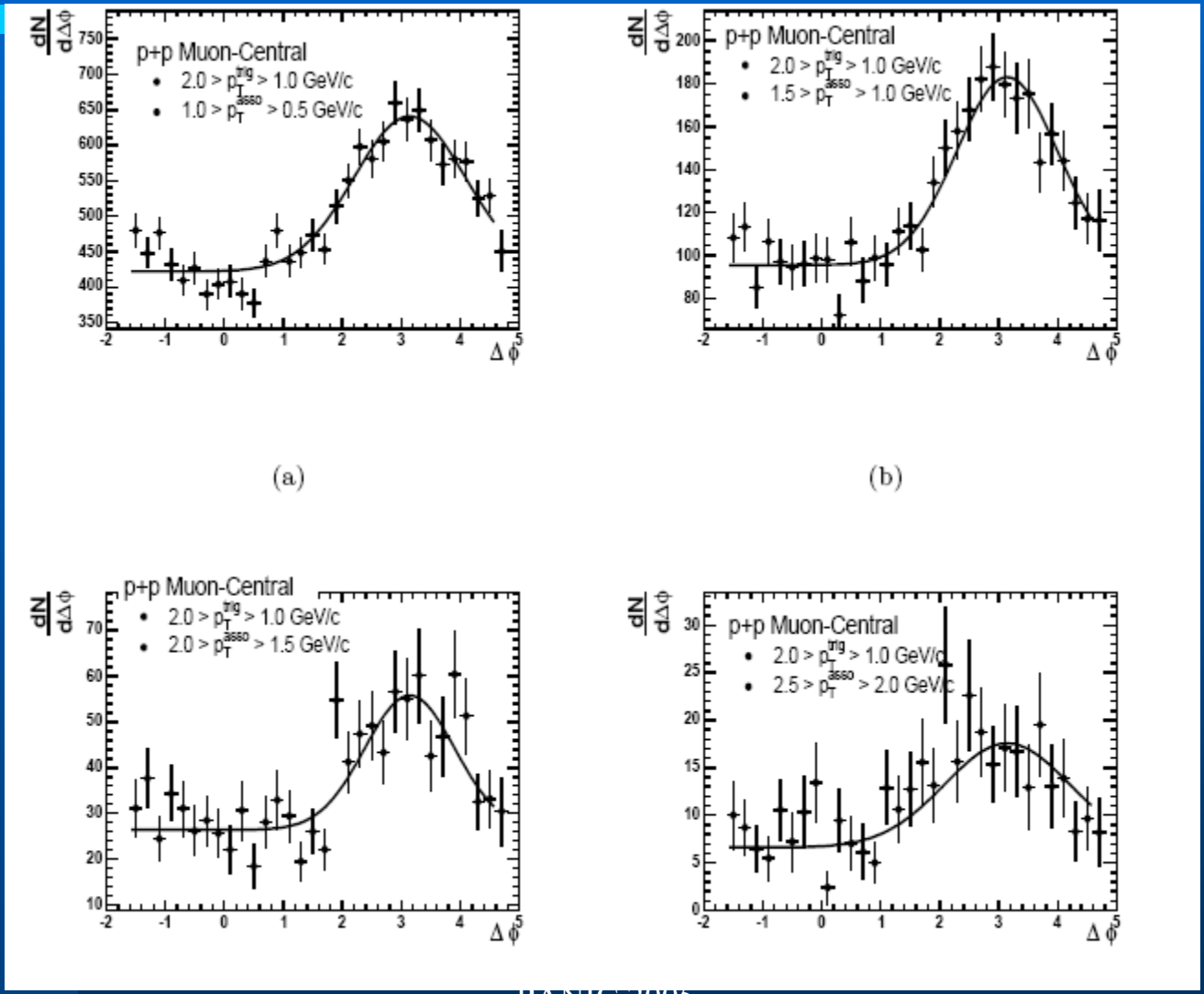
$$PTY^{p+p}(p_T^{trig}, p_T^{asso}) = \frac{N_{jet}^{p+p}(p_T^{trig}) \times m_{jet}(p_T^{asso} \mid p_T^{trig})}{N_{jet}^{p+p}(p_T^{trig}) + N_A^{p+p}(p_T^{trig})}$$

$$PTY^{d+Au}(p_T^{trig}, p_T^{asso}, N_{coll}) = \frac{N_{coll} \times N_{jet}^{p+p}(p_T^{trig}) \times m_{jet}(p_T^{asso} \mid p_T^{trig})}{N_{coll} \times N_{jet}^{p+p}(p_T^{trig}) + S(N_{coll}) \times N_A^{p+p}(p_T^{trig})}$$

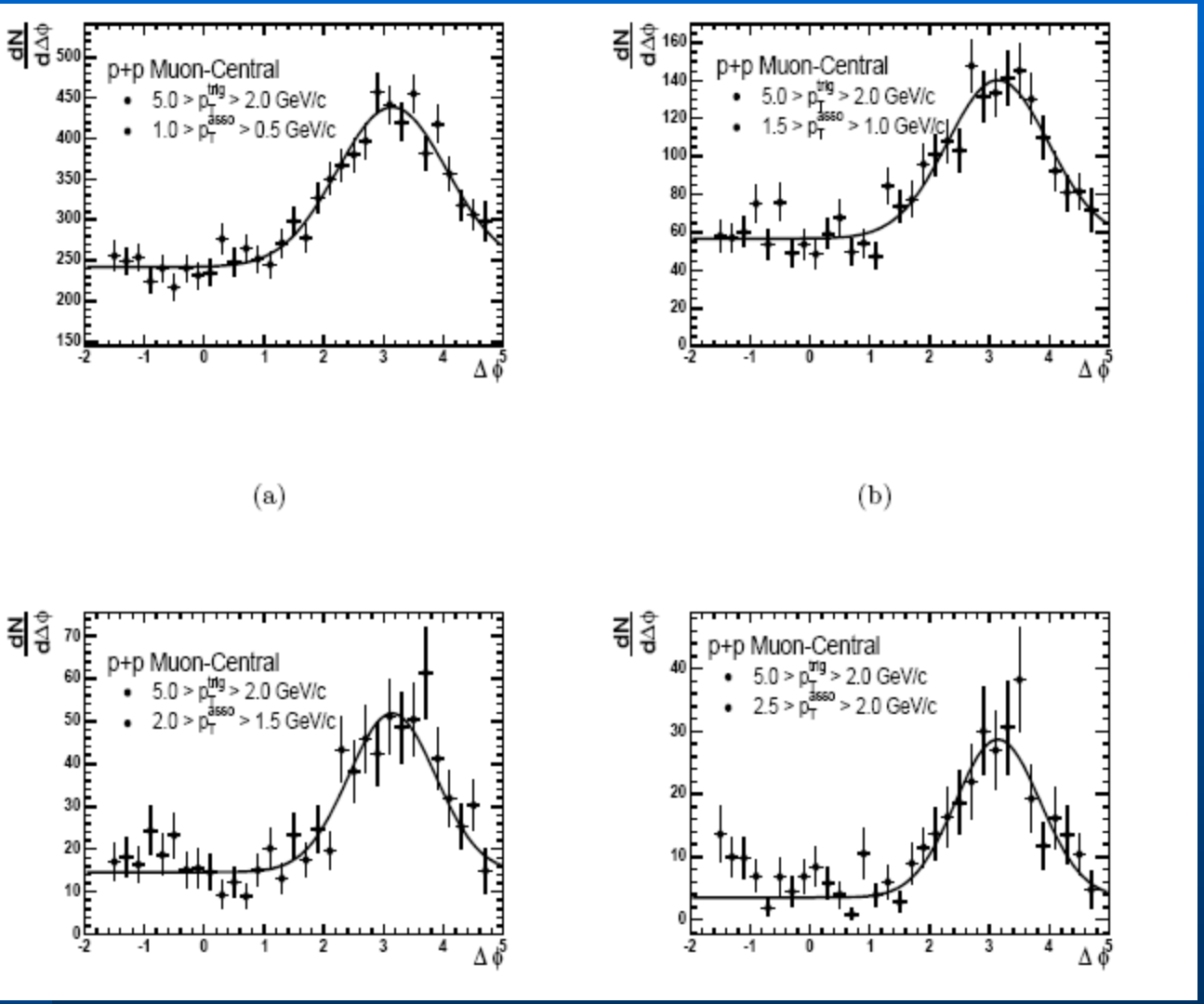
$$I_{dAu}(p_T^{trig}, p_T^{asso}, N_{coll}) = \frac{N_{coll} \times (N_{jet}^{p+p}(p_T^{trig}) + N_A^{p+p}(p_T^{trig}))}{N_{coll} \times N_{jet}^{p+p}(p_T^{trig}) + S(N_{coll}) \times N_A^{p+p}(p_T^{trig})}$$

If S(Ncoll) < Ncoll , then I > 1
If S(Ncoll) > Ncoll , then I < 1

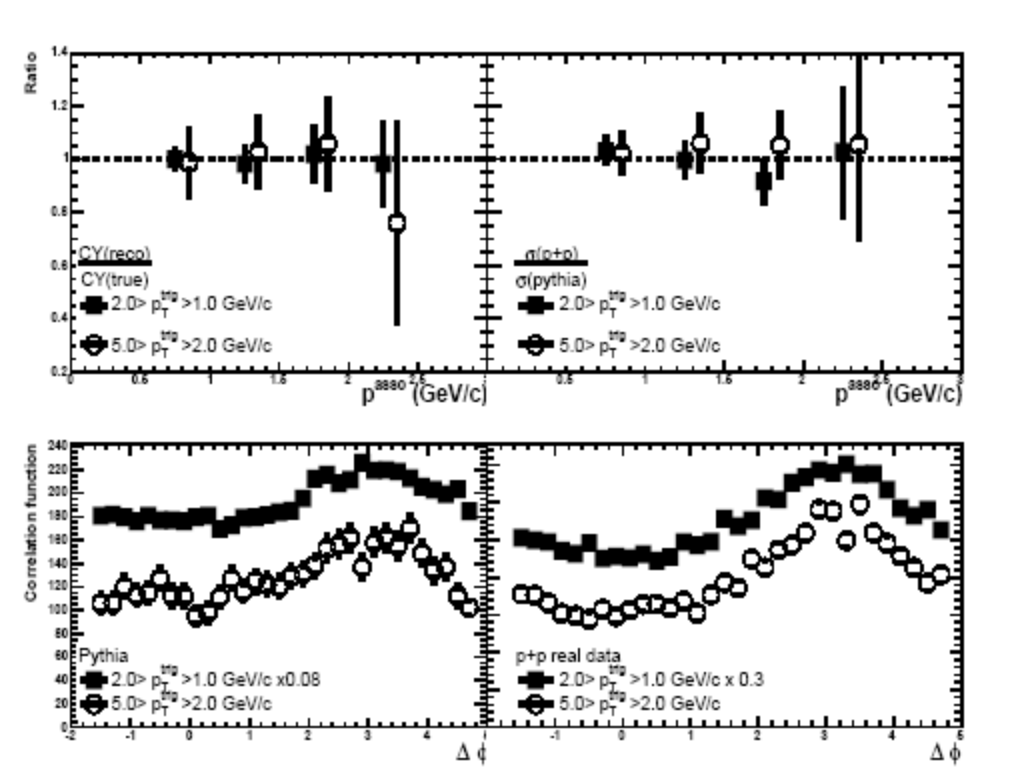
Correlation function in p+p



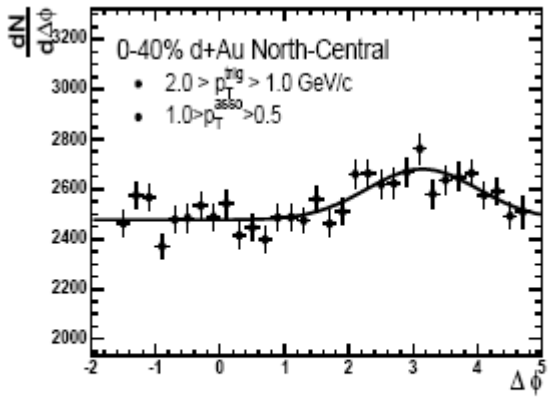
Correlation function in p+p



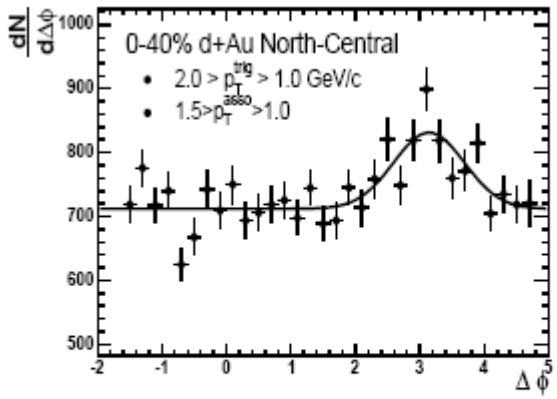
Comparison with PYTHIA



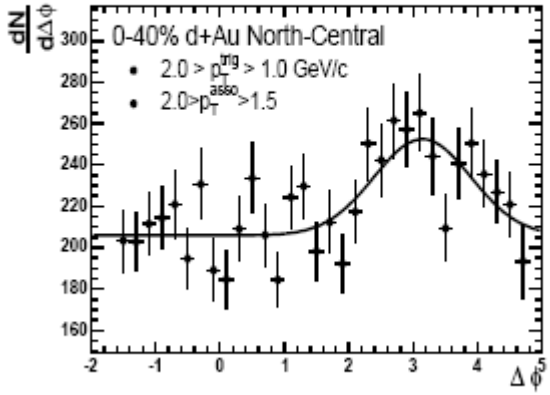
Correlation function for 0-40% d+Au north central

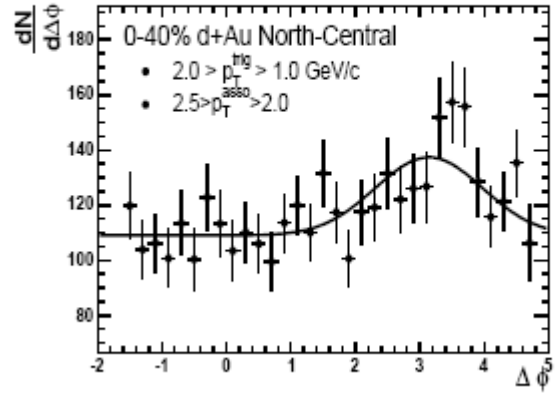


(a)

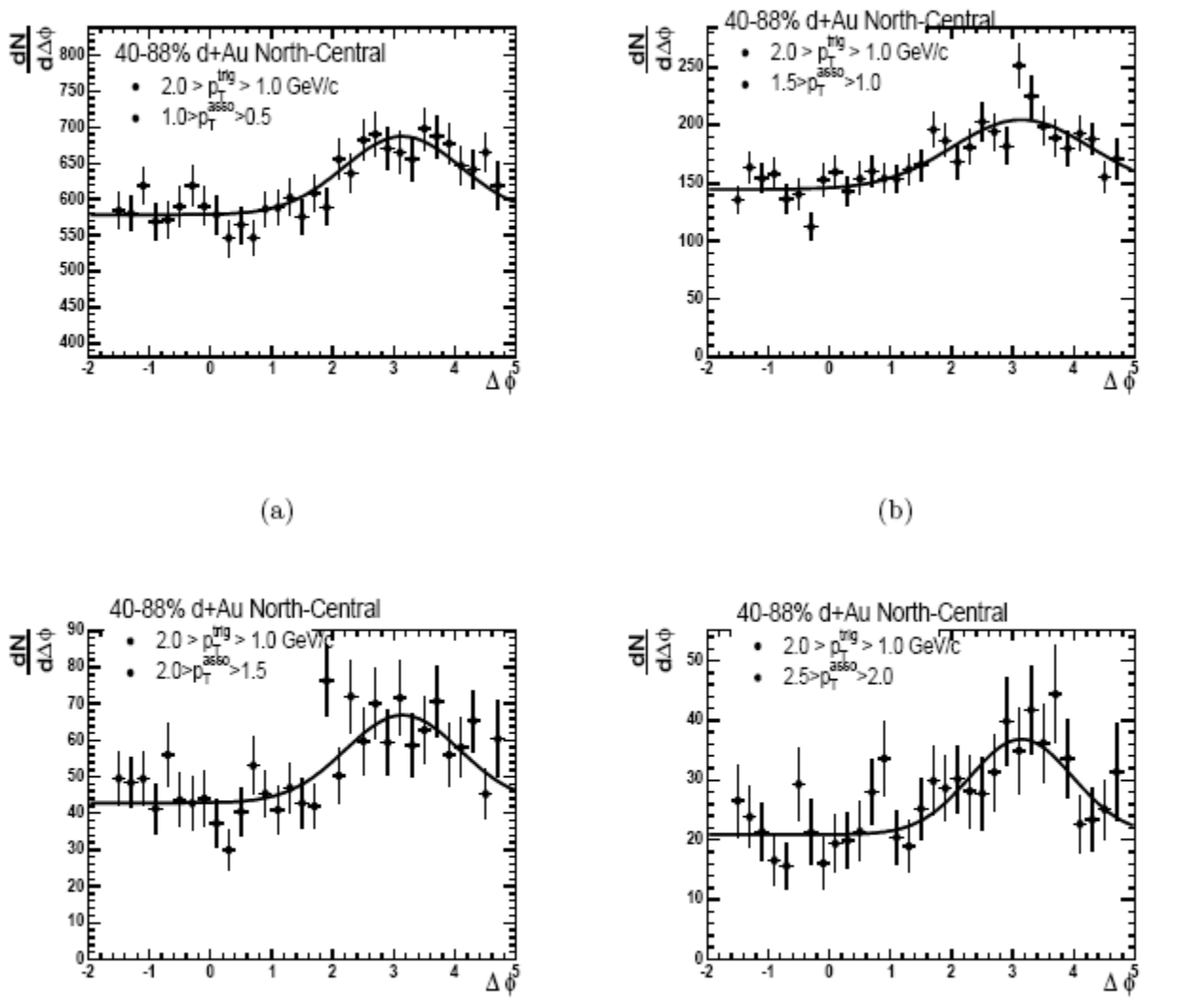


(b)

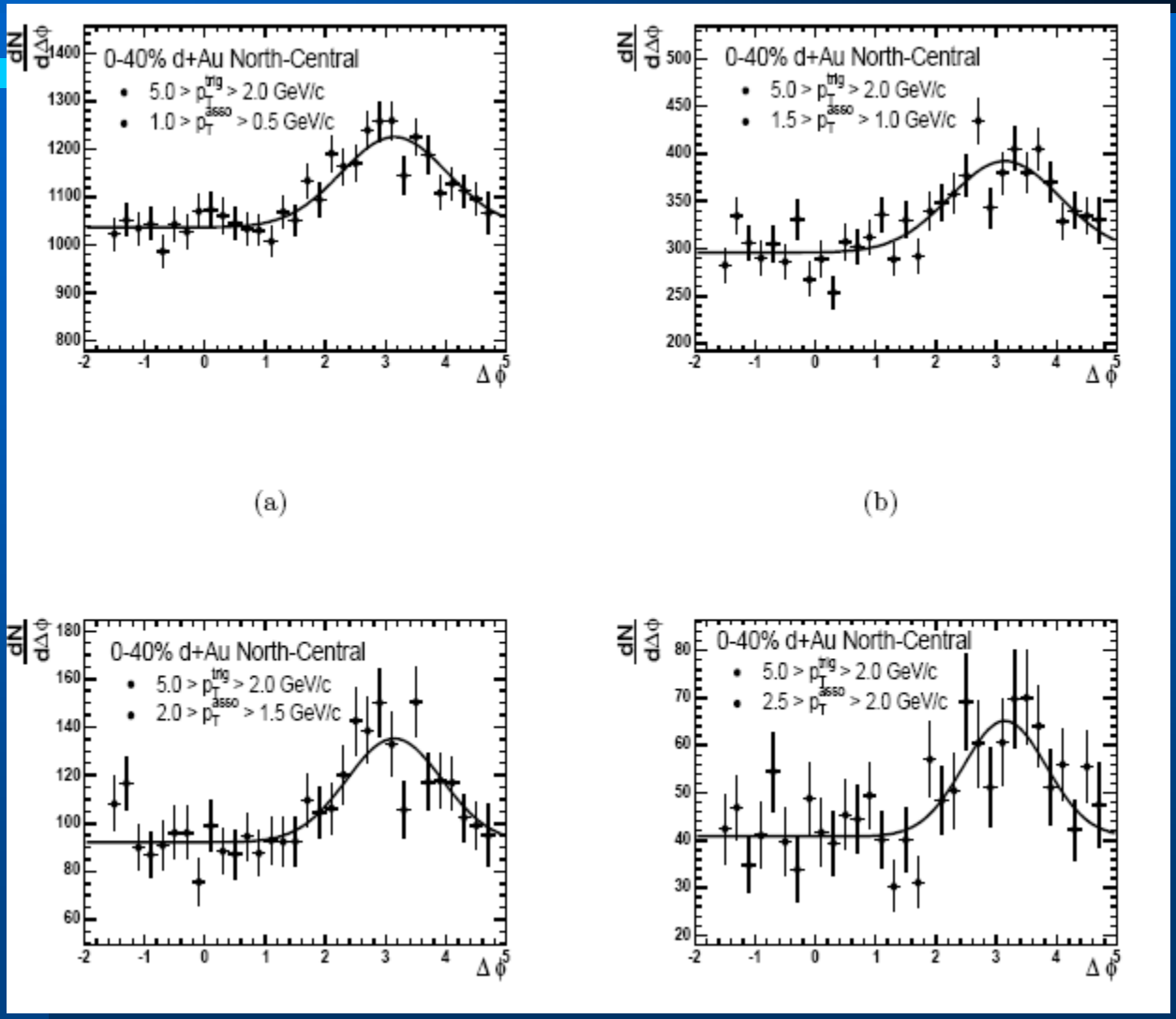




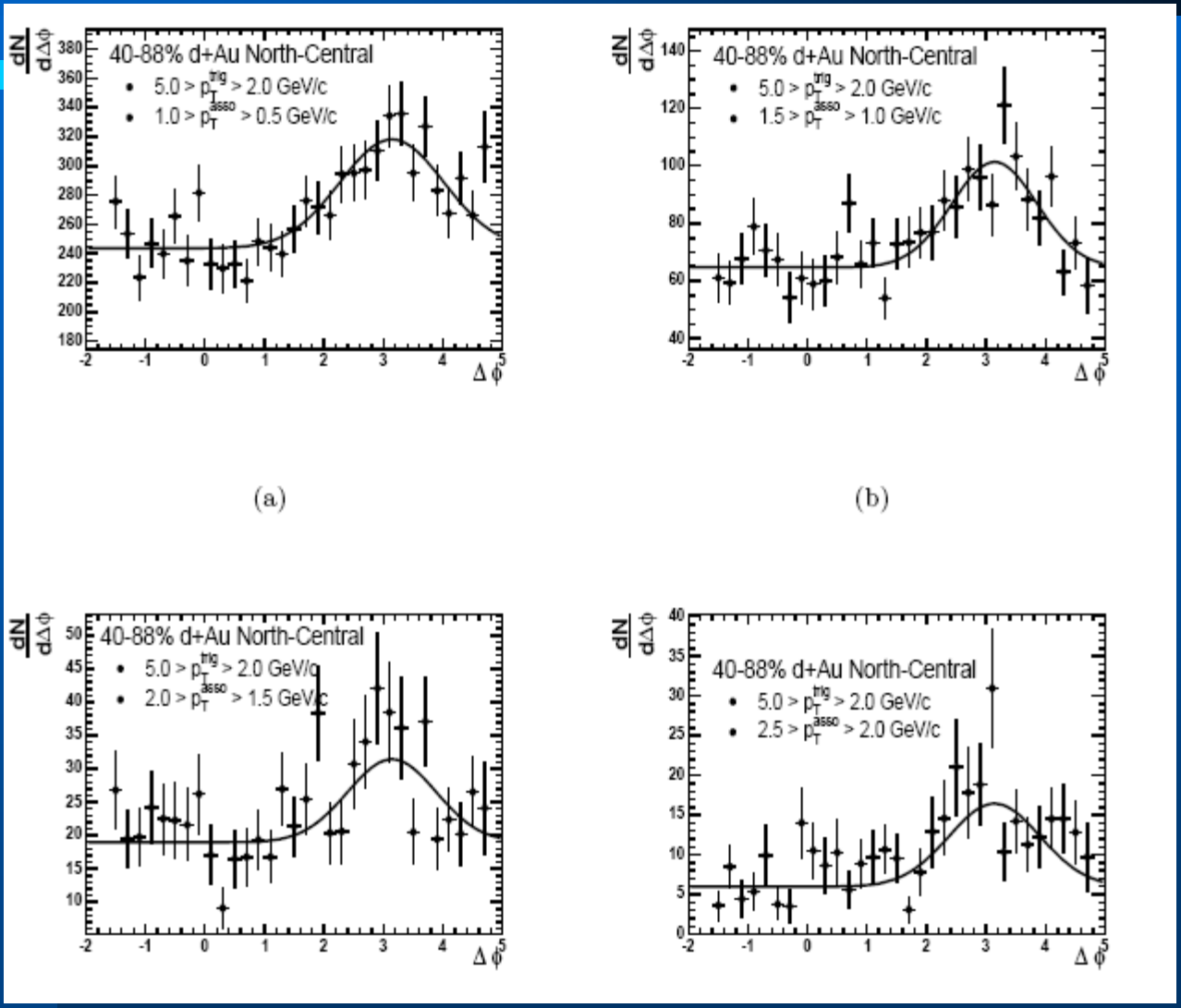
Correlation function for 40-88% d+Au north central



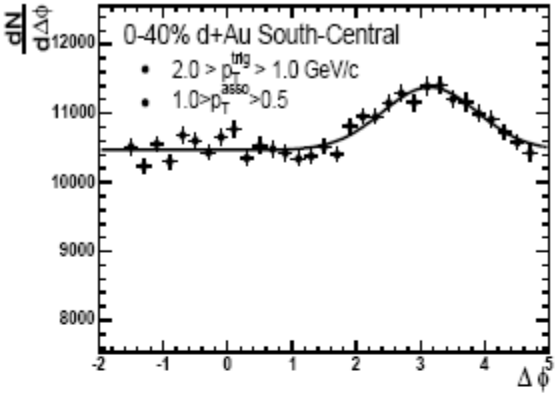
Correlation function for 0-40% d+Au north central



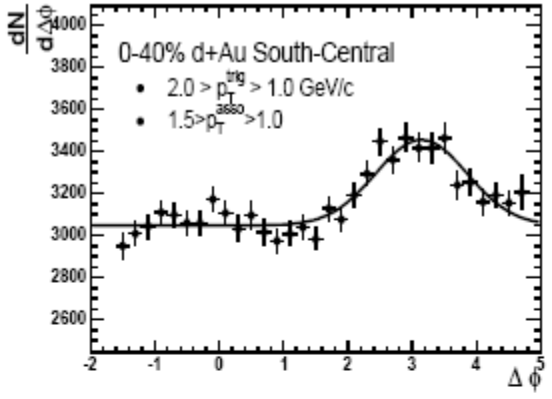
Correlation function for 40-88% d+Au north central



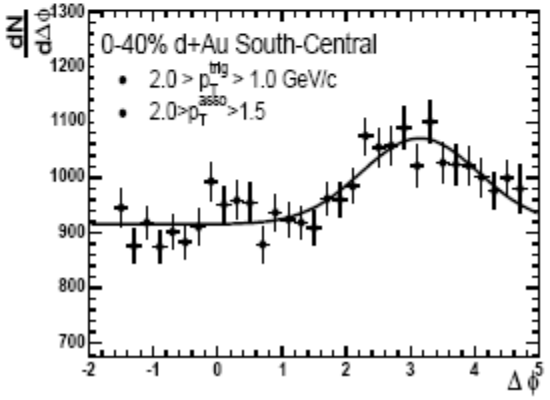
Correlation function for 0-40% d+Au south central

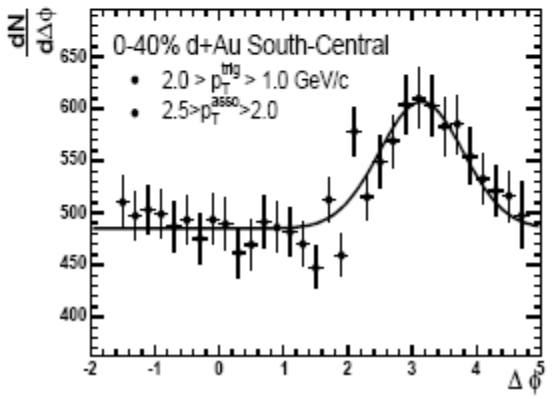


(a)

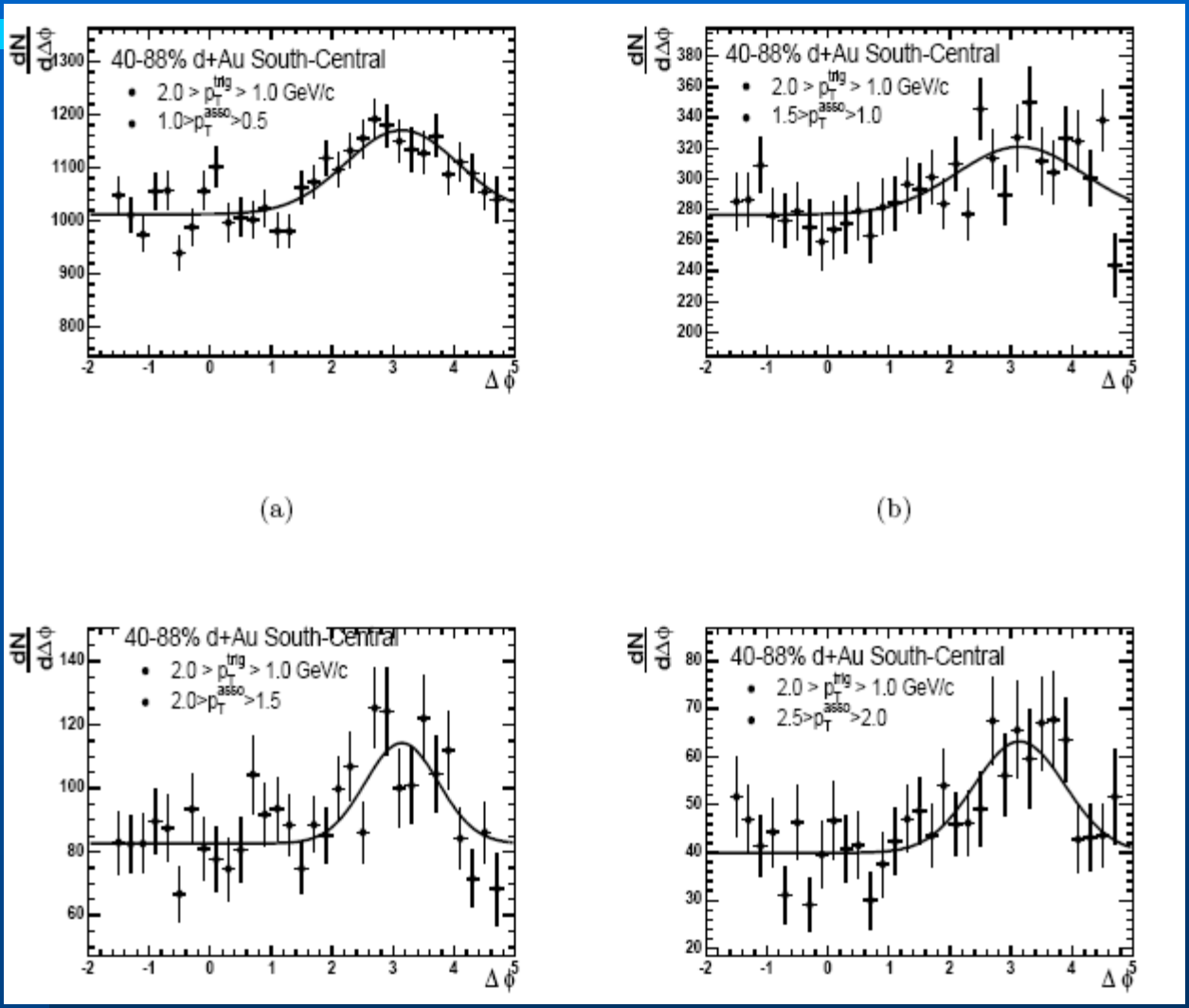


(b)

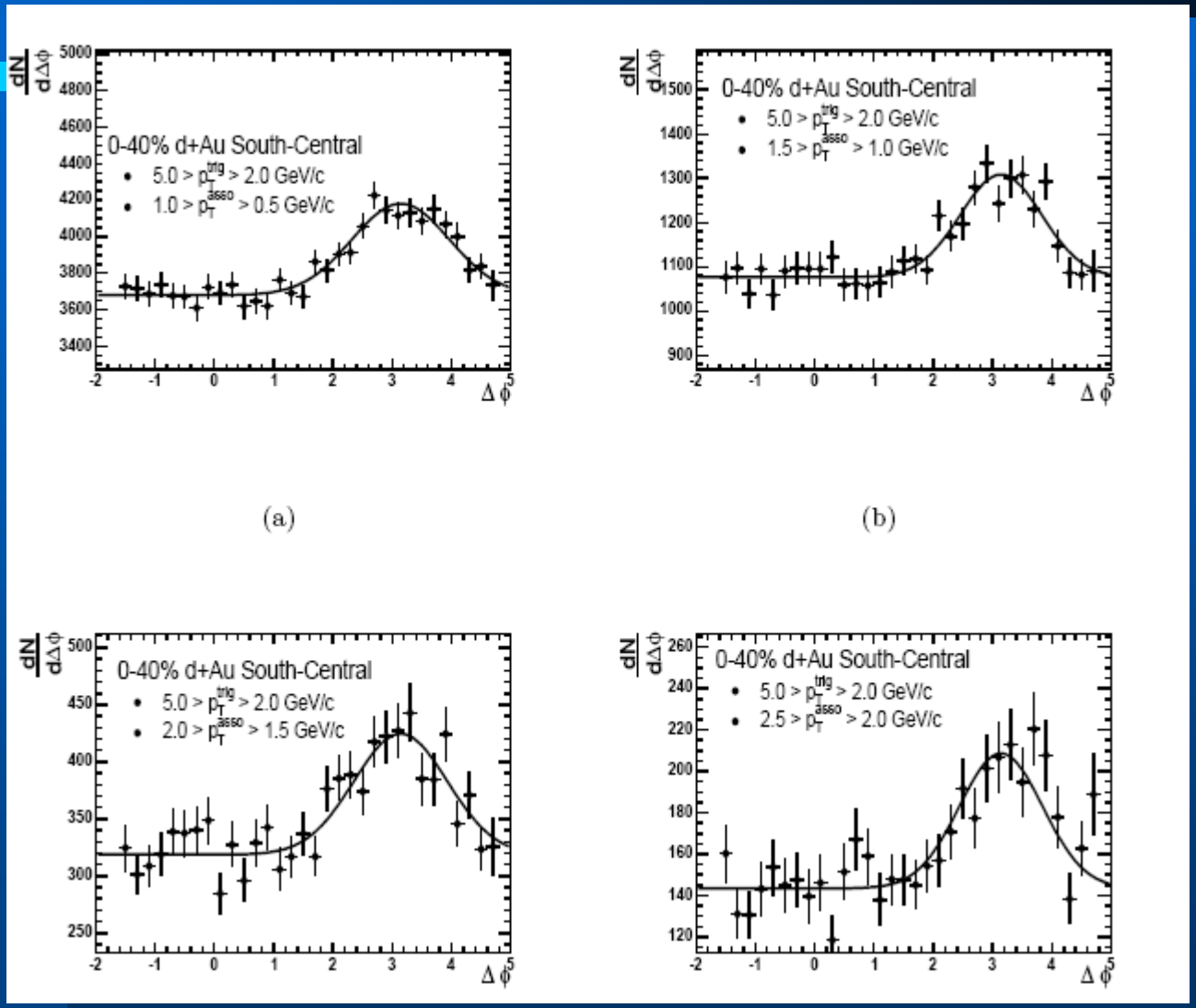




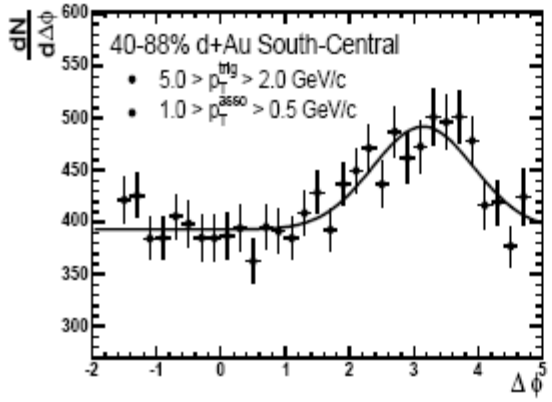
Correlation function for 40-88% d+Au south central



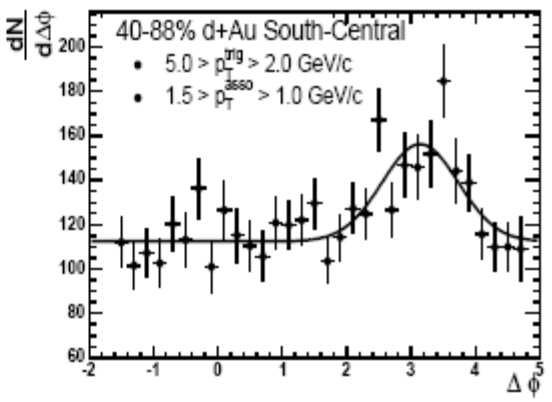
Correlation function for 0-40% d+Au south central



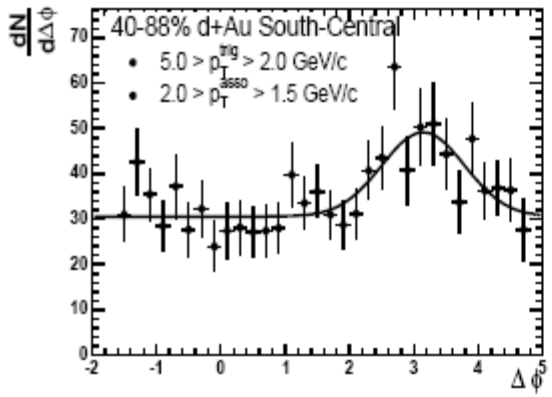
Correlation function for 40-88% d+Au south central



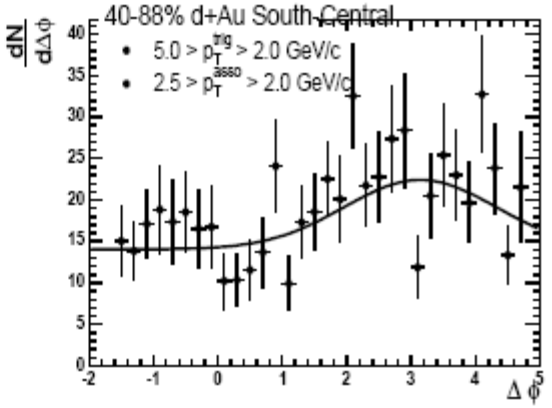
(a)



(b)



(c)



(d)